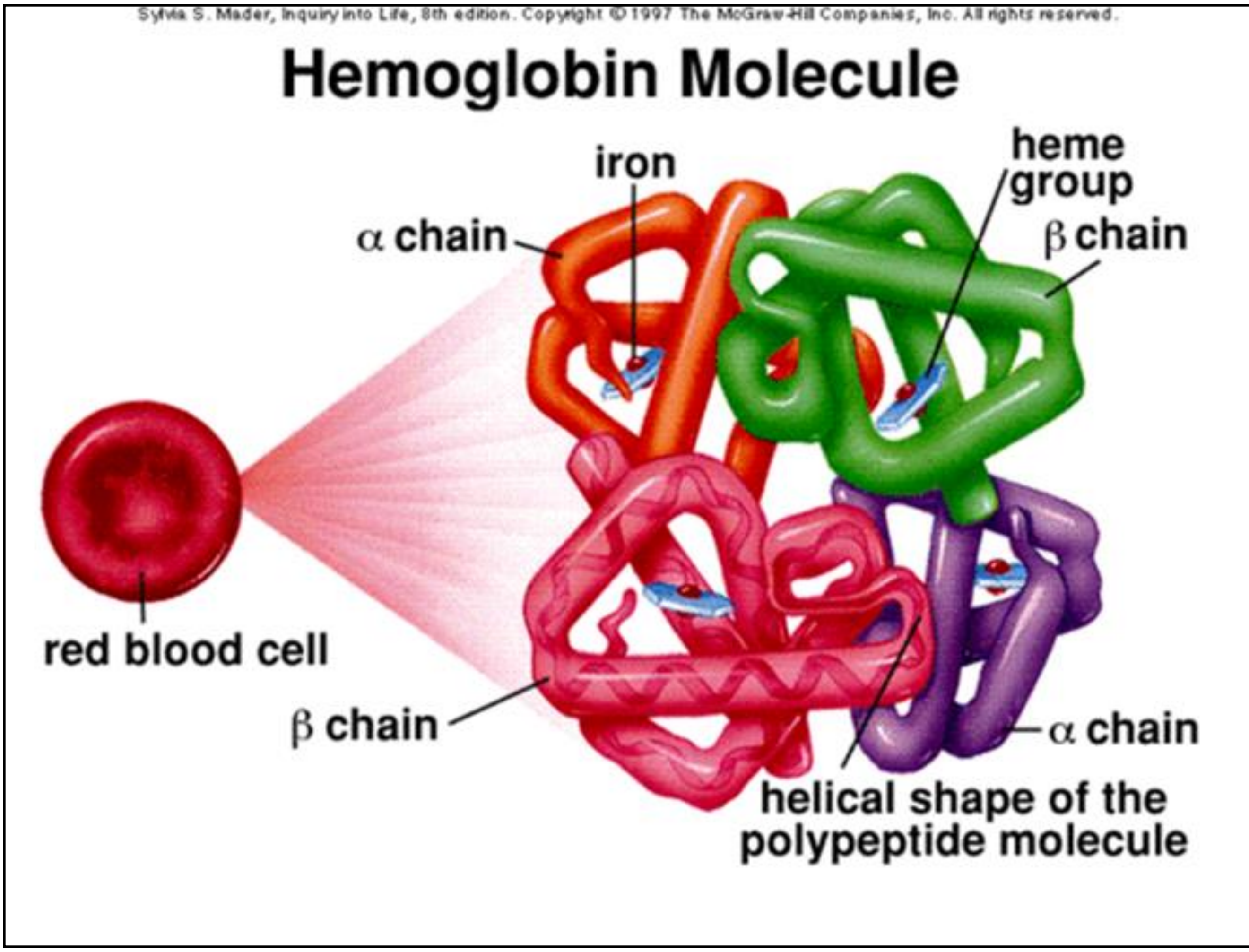
Big Idea 4 - Interactions

Part 2 – Competition & Cooperation are important aspects of biological systems



I. Models of Molecular Interactions

Oxygen transport

Hemoglobin

binds oxygen in a cooperative fashion

Transports & delivers O_2 to body tissues

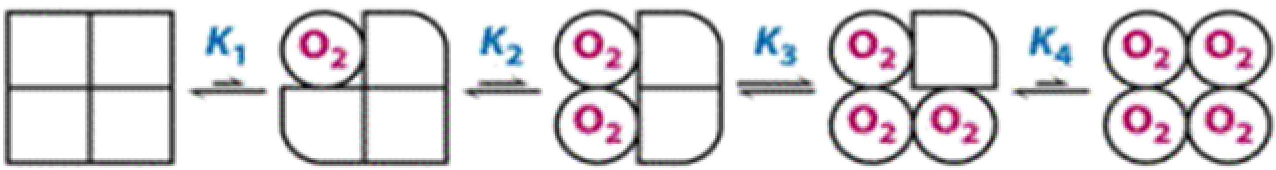
Picks up CO_2 for disposal

Myoglobin binds oxygen aggressively

Binds oxygen for use in **muscles**

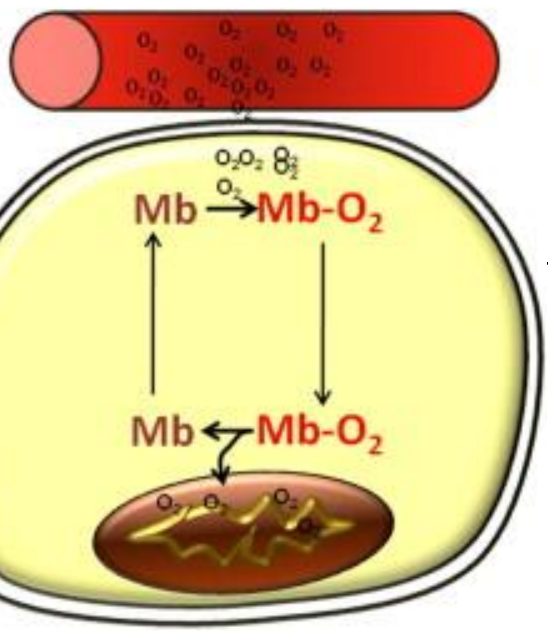
Hemoglobin exhibits cooperativity

- Each oxygen bound increases affinity for more oxygen



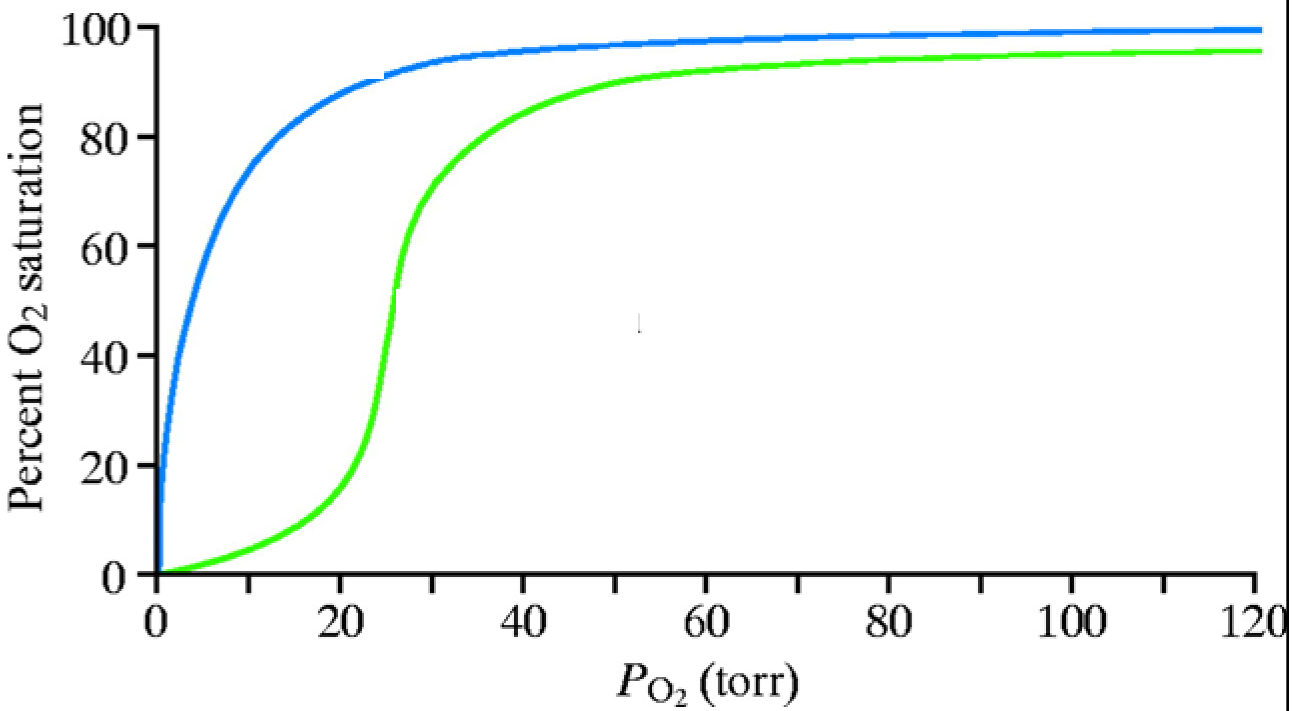
Myoglobin does not exhibit cooperativity

- Myoglobin binds 1 oxygen from blood



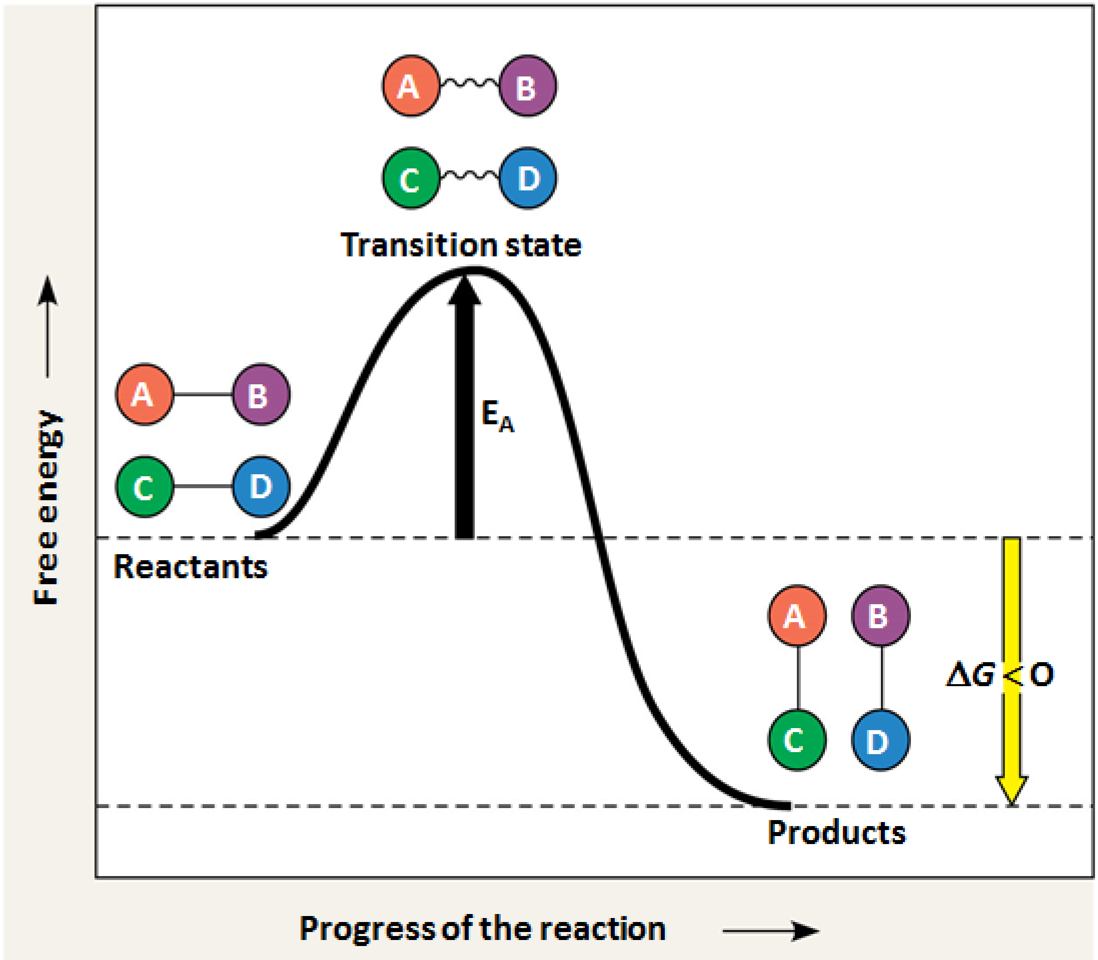
What does this imply about myoglobin's affinity requirements as compared to hemoglobin???

Hb vs. Mb



Which line represents **Hb** and which represents **Mb**? Justify your response with data from the previous slide.

Figure 8.12

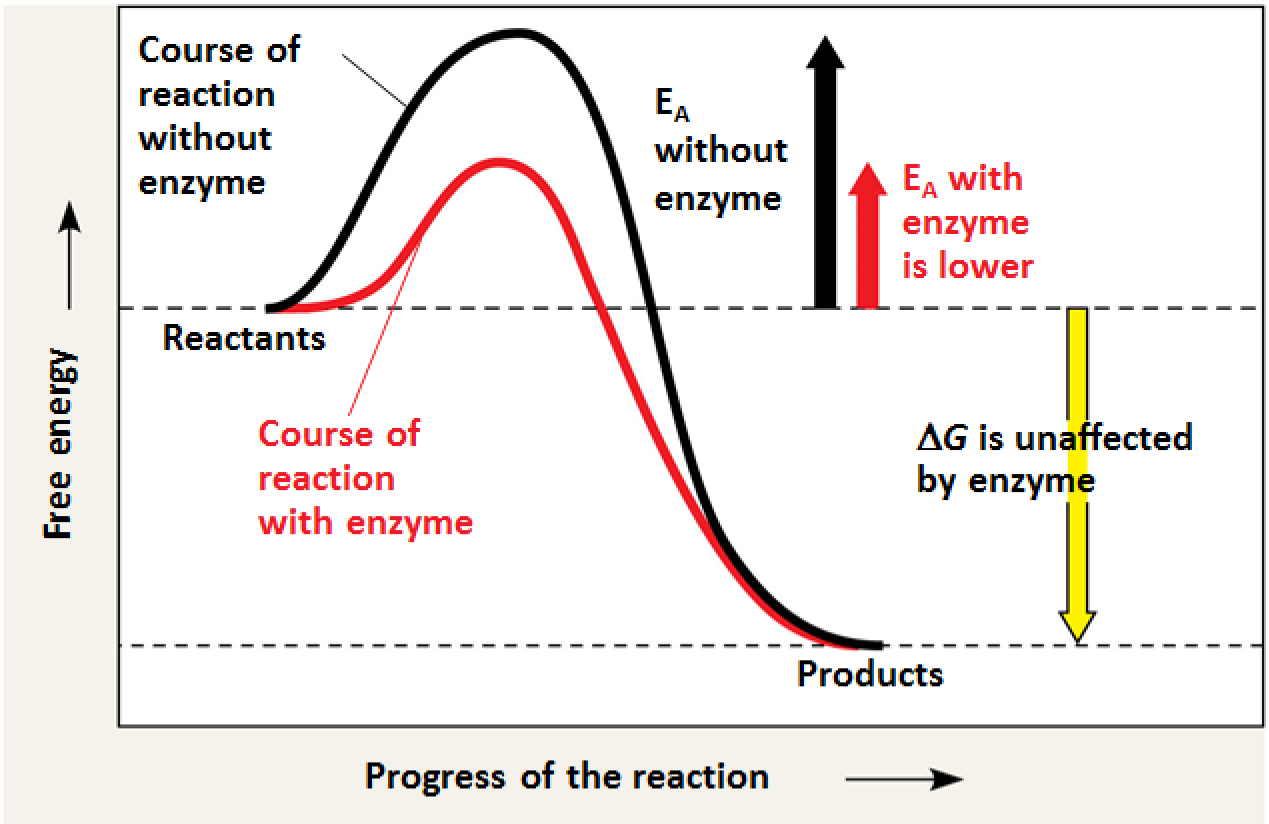


Every chemical reaction between molecules involves bond breaking and bond forming.

The initial energy needed to start a chemical reaction is called the free energy of activation, or **activation energy (E_A)**.

Activation energy is often supplied in the form of thermal energy that the reactant molecules absorb from their surroundings.

Figure 8.13



Enzymes

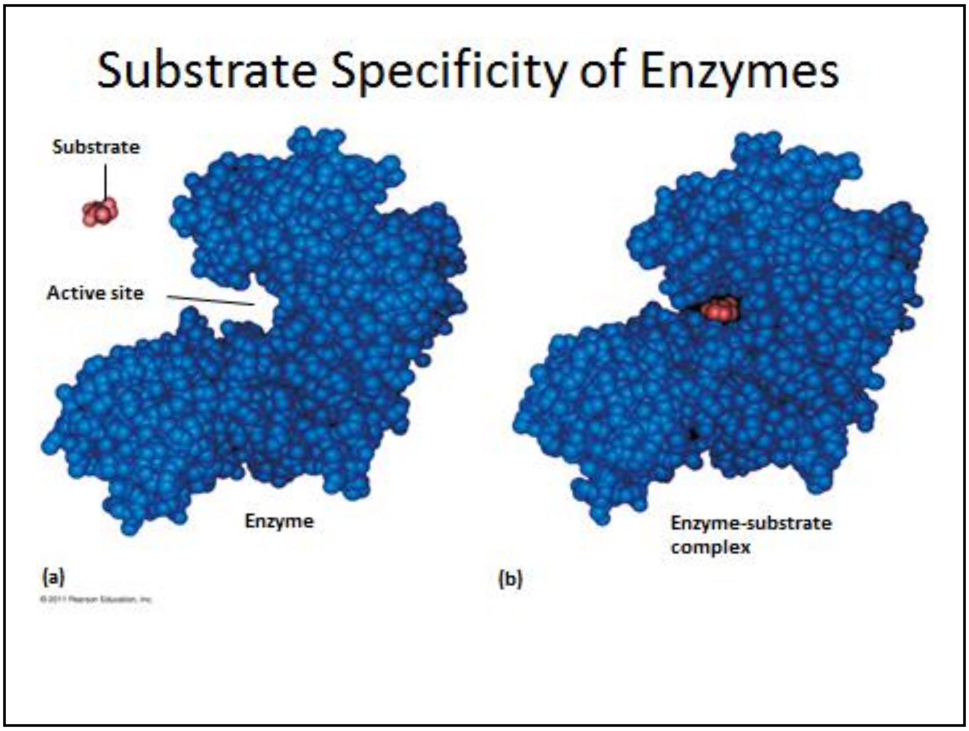
Speed up metabolic reactions by lowering energy barriers

A **catalyst** is a chemical agent that speeds up a reaction without being consumed by the reaction

An **enzyme** is a catalytic protein

Enzymes catalyze reactions by lowering the E_A barrier

Enzymes do not affect the change in free energy (ΔG); instead, they hasten reactions that would occur eventually

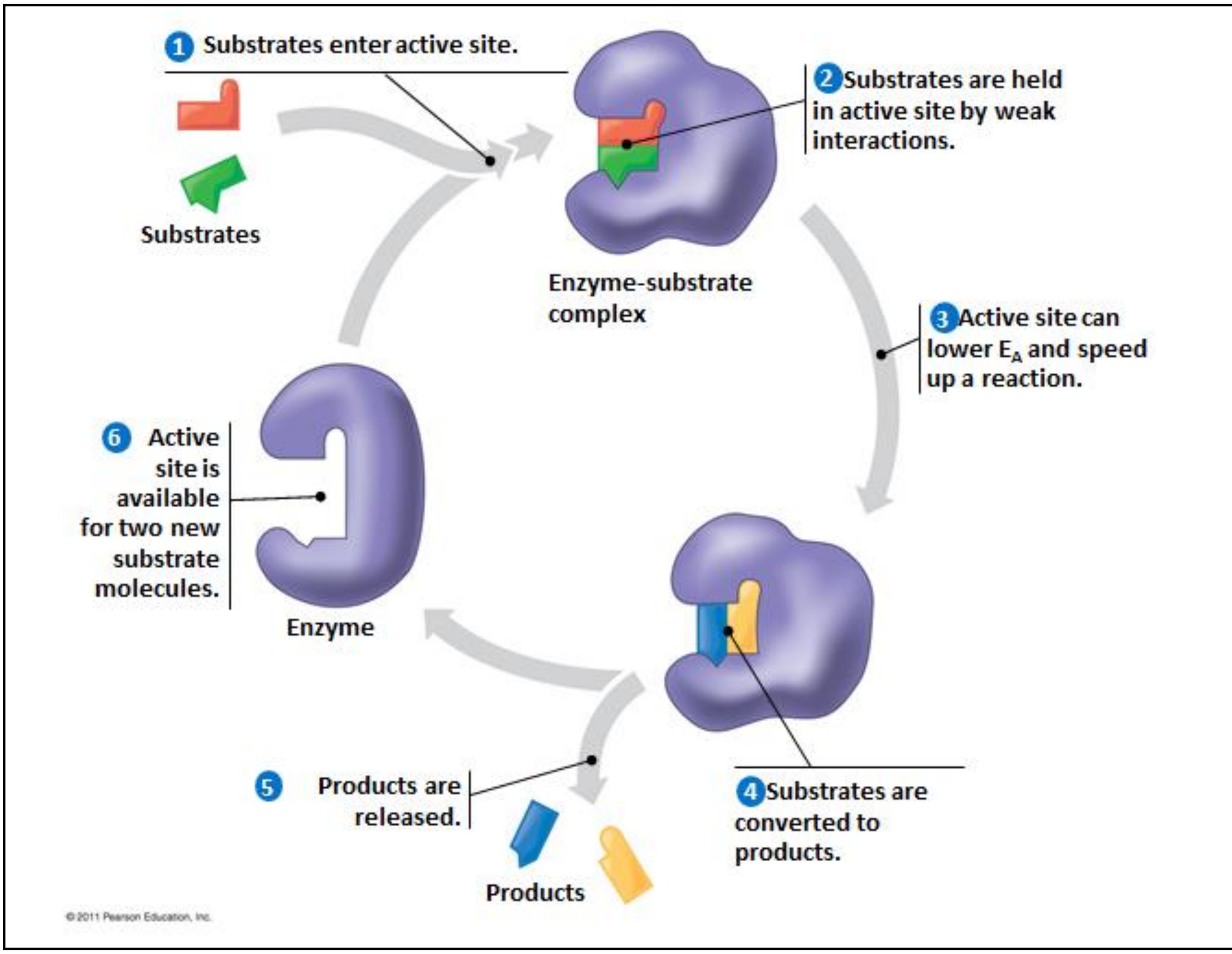


The reactant that an enzyme acts on is called the enzyme’s **substrate.**

The enzyme binds to its substrate, forming an **enzyme-substrate complex.**

The **active site** is the region on the enzyme where the substrate binds.

Induced fit of a substrate brings chemical groups of the active site into positions that enhance their ability to catalyze the reaction.



In an enzymatic reaction, the substrate binds to the active site of the enzyme

The active site can **lower an E_A** barrier by

- Orienting substrates correctly
- Straining substrate bonds
- Providing a favorable microenvironment
- Covalently bonding to the substrate

Effects of Local Conditions on Enzyme Activity

- An enzyme's activity can be affected by
  - General environmental factors, such as temperature and pH
  - Chemicals that specifically influence the enzyme

Each enzyme has an optimal temperature in which it can function

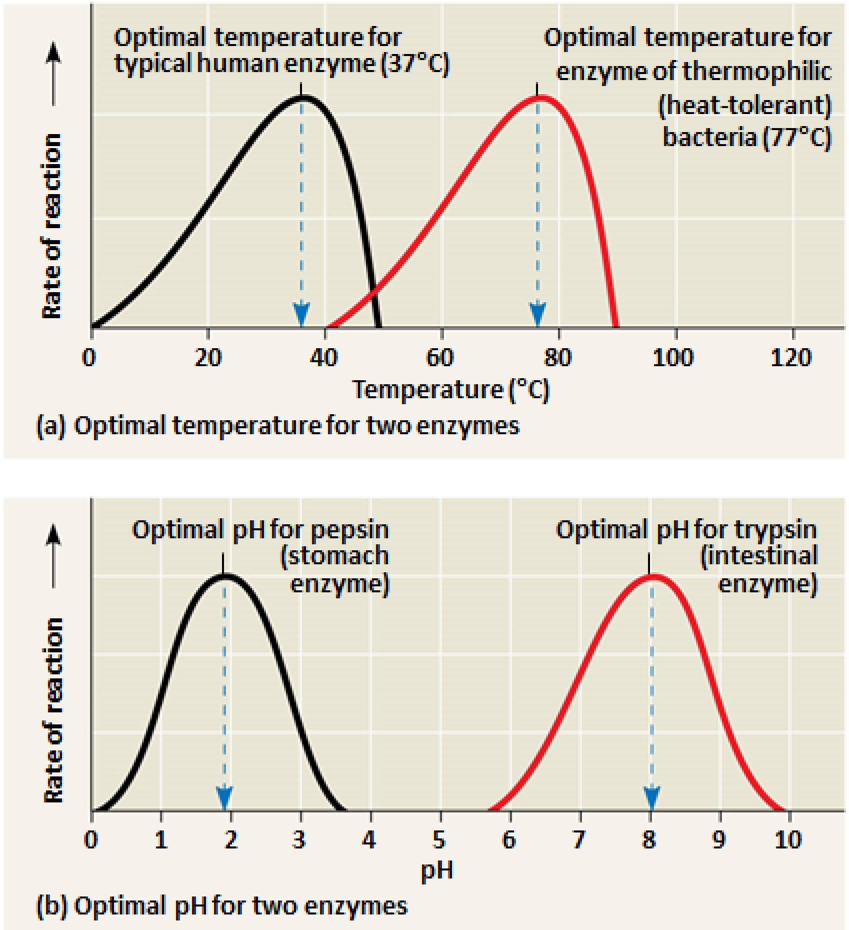
WHY???

Each enzyme has an optimal pH in which it can function

WHY???

Optimal conditions favor the most active shape for the enzyme molecule

Figure 8.16

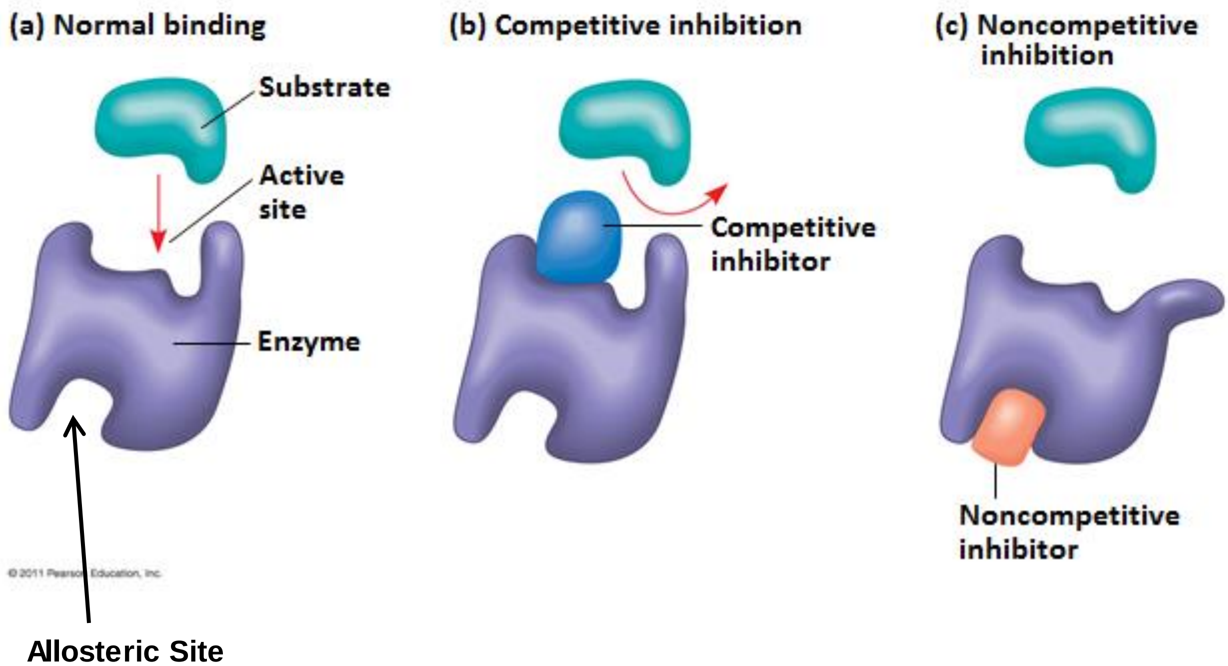


For each graph, provide an example of a specific enzyme or organism body system that would have this enzyme. Justify your responses.

Cofactors

- **Cofactors** are nonprotein enzyme helpers
- Cofactors may be inorganic (such as a metal in ionic form) or organic
- An organic cofactor is called a **coenzyme**
- Coenzymes include vitamins

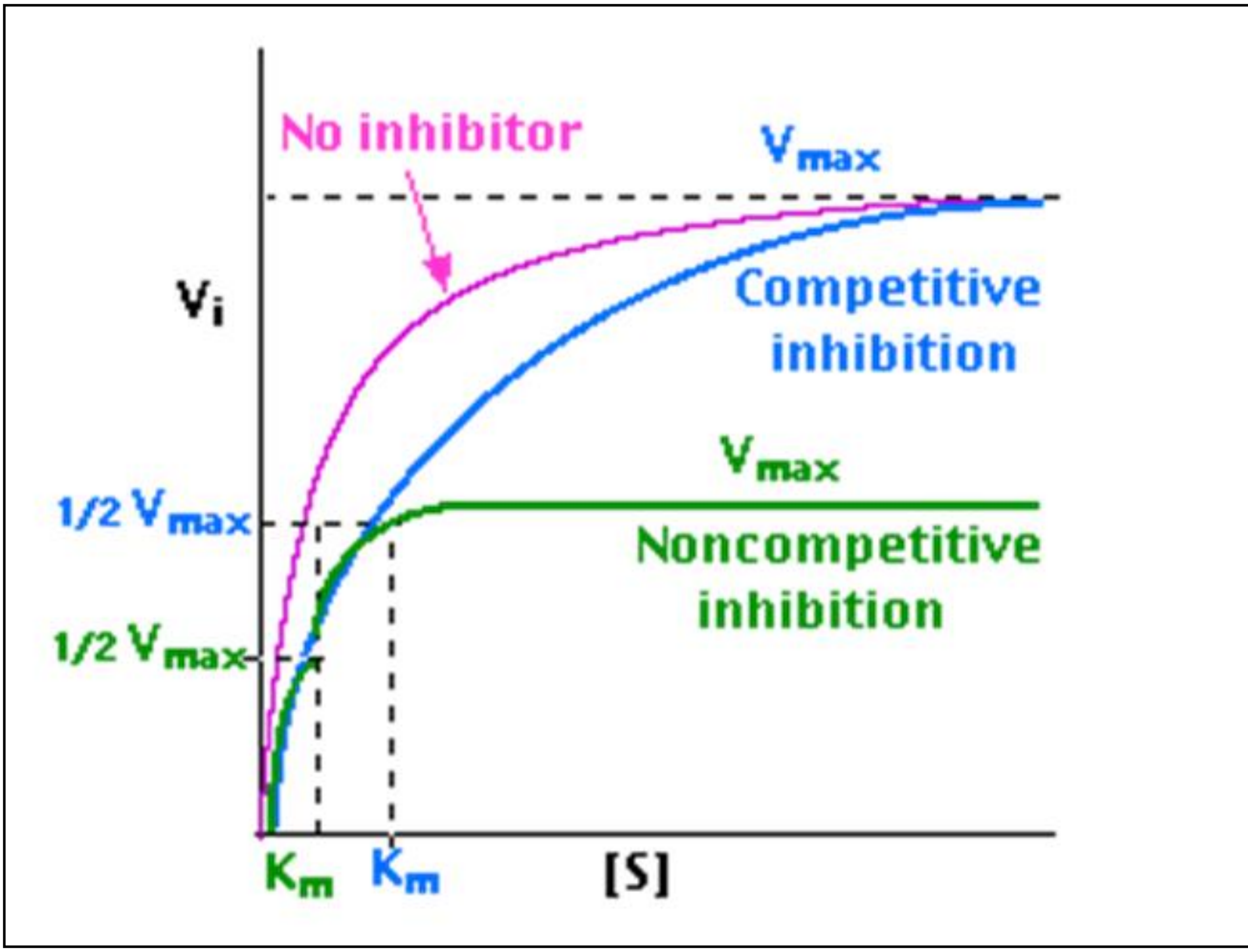
Enzyme Inhibitors



Competitive inhibitors bind to the *active site* of an enzyme, competing with the substrate.

Noncompetitive inhibitors bind to another part of an enzyme (*allosteric site*), causing the enzyme to change shape and making the active site less effective or completely ineffective.

Examples of inhibitors include toxins, poisons, pesticides, and antibiotics

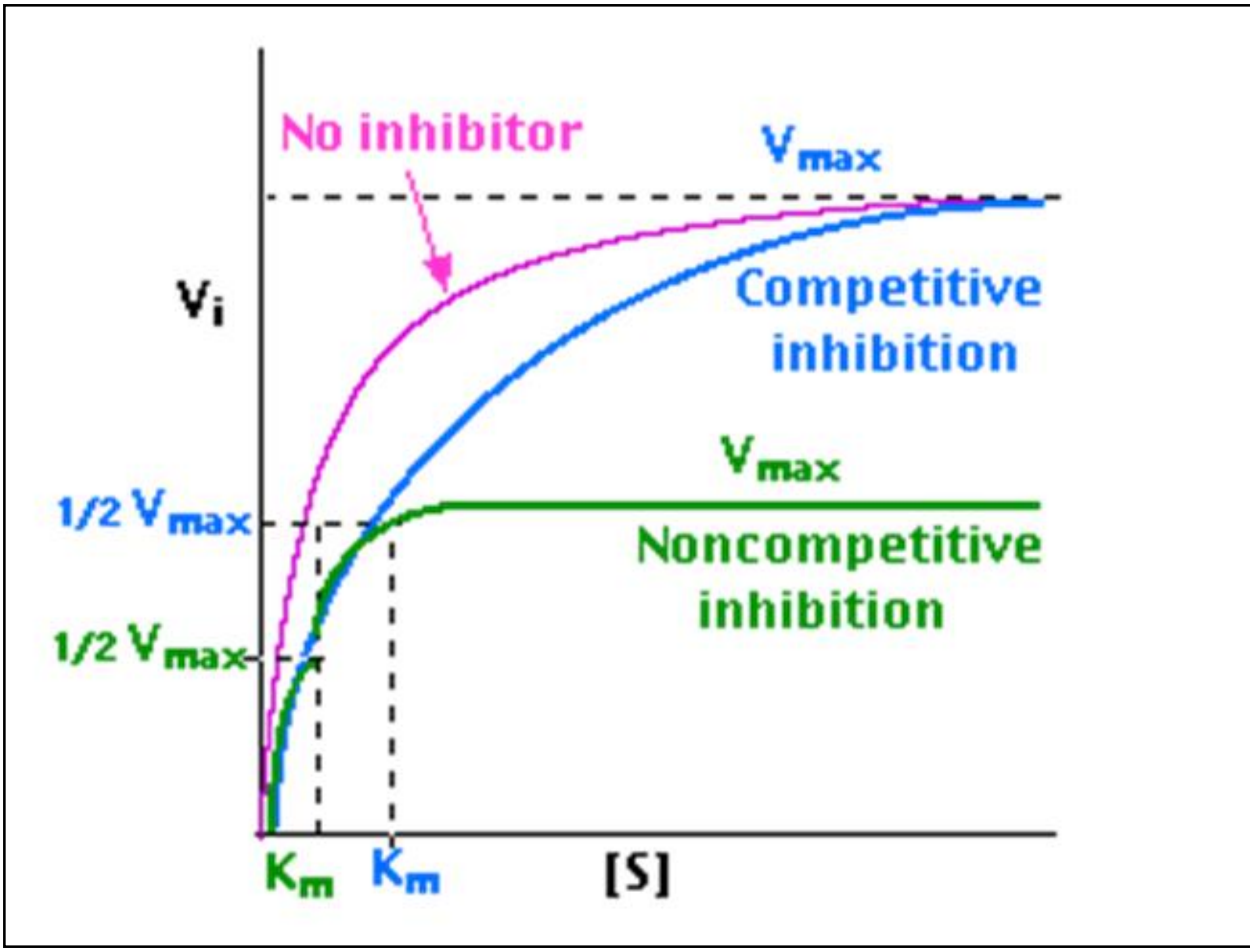


Vmax = maximum velocity of the enzyme; used to determine *maximum* rate of the enzyme as a function of increasing substrate concentration.

1/2 Vmax = Half the value of Vmax; used as a more accurate measure of enzyme's *steadiest* *rate* as a function of increasing substrate concentration.

Km = The **substrate concentration** at the **1/2 Vmax value** (Used to determine how *efficiently* the enzyme is converting substrate to product.

[S] = Concentration of the substrate; used to determine how the enzyme functions from low to high levels of substrate.



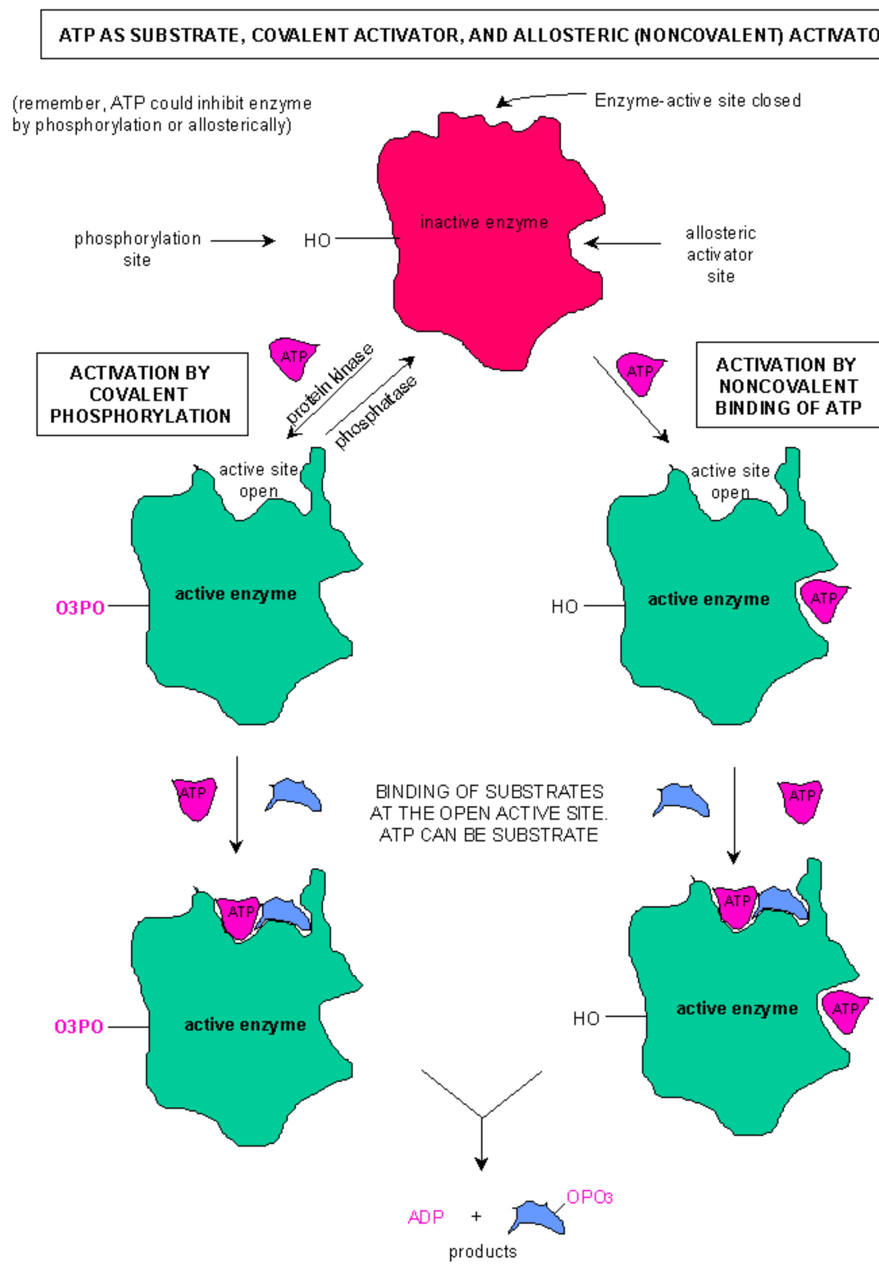
Using all the information on p.12-13, explain the trends in the graphs in terms of enzyme efficiency in the presence of a competitive vs. a non-competitive inhibitor.

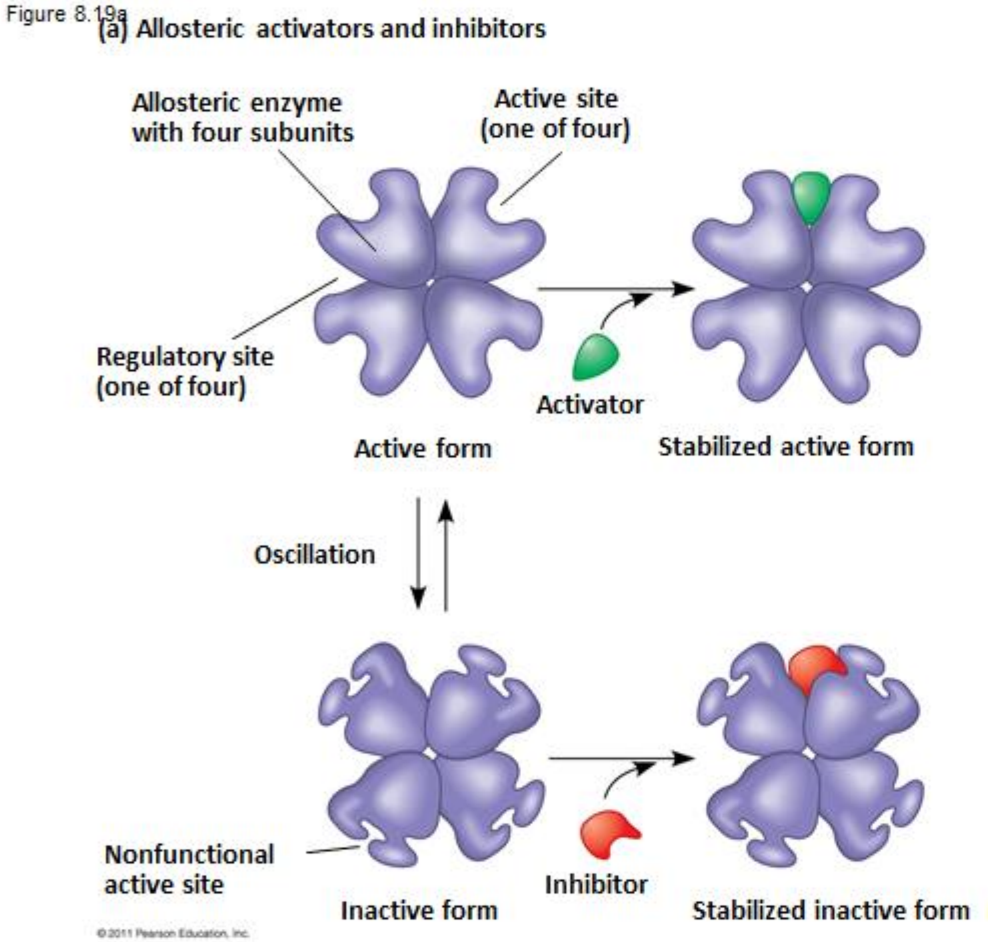
Which type of inhibitor would be the most harmful? Explain.

Is the non-competitive inhibitor in this example less effective or completely ineffective? Explain your reasoning.

Regulation of enzyme activity helps control metabolism

- Chemical chaos would result if a cell's metabolic pathways were not tightly regulated
- A cell does this by switching on or off the genes that encode specific enzymes or by regulating the activity of enzymes





Allosteric Regulation of Enzymes

Allosteric regulation may either inhibit or stimulate an enzyme's activity

Allosteric regulation occurs when a regulatory molecule binds to a protein at one site and affects the protein's function at another site

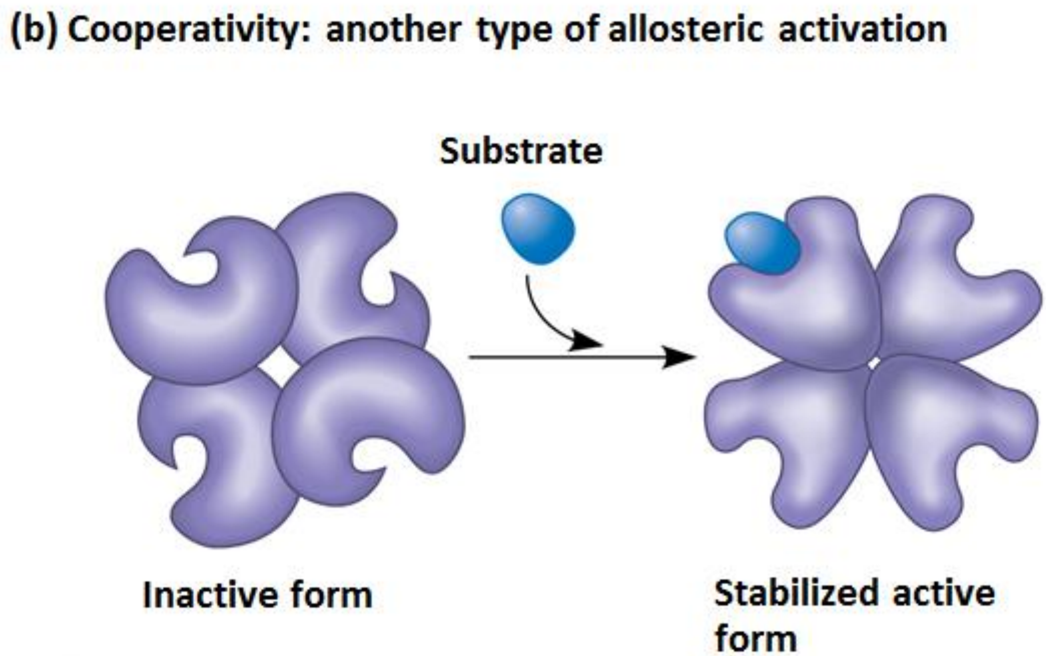
Most allosterically regulated enzymes are made from polypeptide subunits (Quaternary Structure)

Each enzyme has active and inactive forms

The binding of an **activator** stabilizes the active form of the enzyme

The binding of an **inhibitor** stabilizes the inactive form of the enzyme

Figure 8.19b



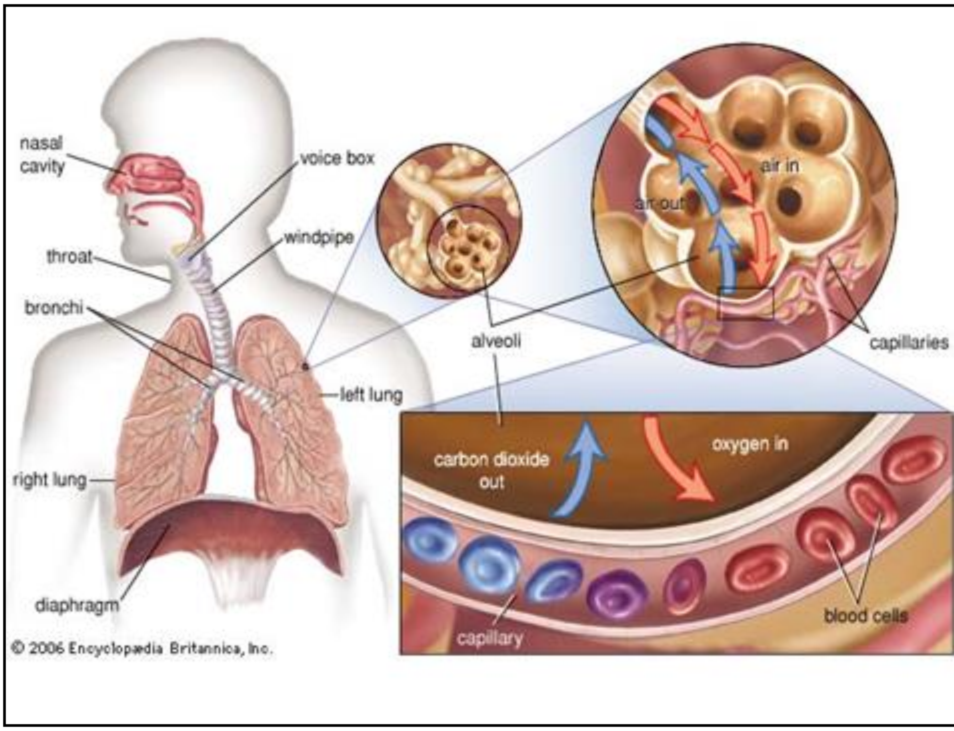
Cooperativity is a form of allosteric regulation that can amplify enzyme activity

One substrate molecule primes an enzyme to act on additional substrate molecules more readily

Cooperativity is allosteric because binding by a substrate to one active site affects catalysis in a different active site

Cellular Cooperativity

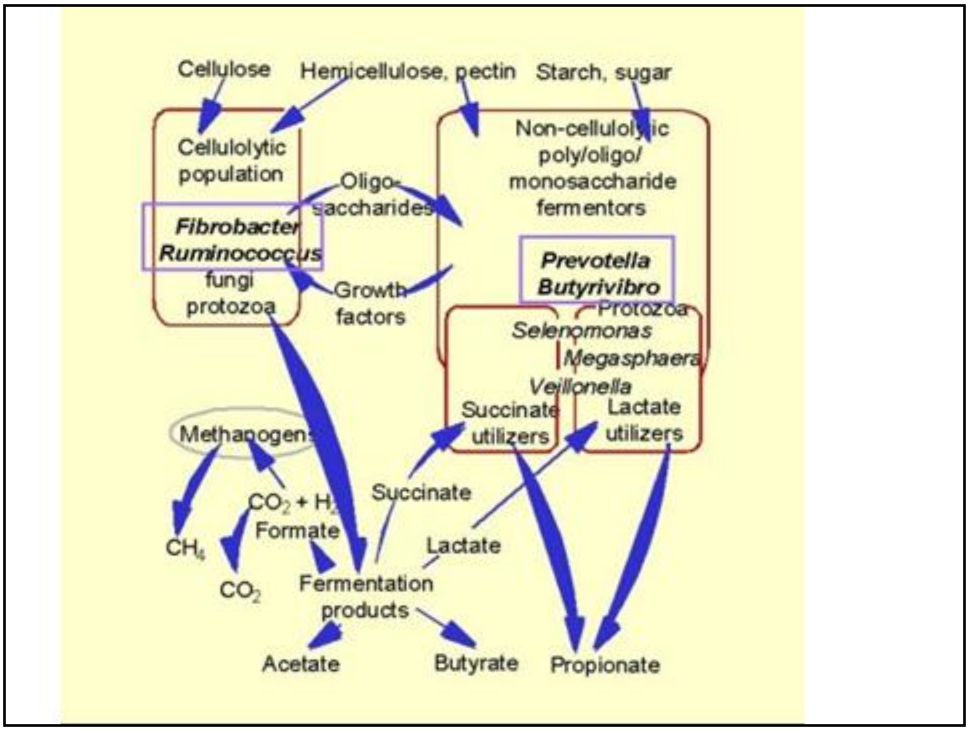
- Cooperation among cell parts contributes to a cell's specialty
  - Nerve cells
    - Numerous Ion channels in membrane
    - Mitochondria for ATP
    - Vesicles with neurotransmitters
  - White Blood Cells
    - Lysosomes for pathogen digestion
    - Golgi to produce lysosomes
    - Specialized membrane receptors



Organ System Cooperativity

Gas exchange

- Alveoli in lungs
- Capillaries for O_2/CO_2 exchange



Unicellular Cooperation

Microbial communities each produce certain compounds.

Their individual efforts benefit the community (and host organism in the case of mutualistic bacteria).

Cow Rumen Microorganism Community

Community Interactions

- How Organisms affect each other
- Analyzed by positive/negative outcomes

Predation

- Predator eats prey
- Win / Lose

Herbivory

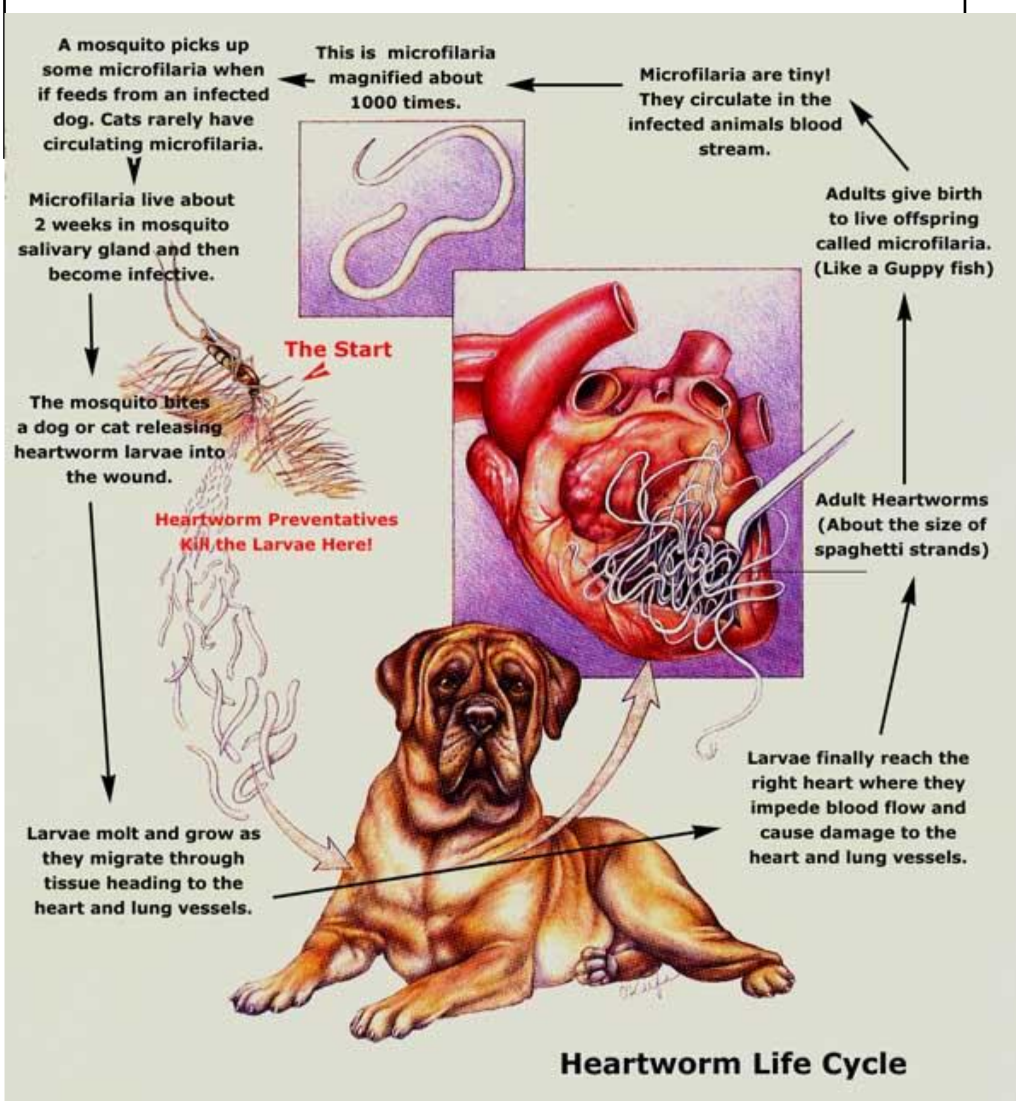
Animal eats a plant

Win/Lose

Parasitism

- Parasite lives inside host and harms the host.
  - Eats parts of the host
  - Reproduces inside of the host

- Win / Lose



Competition

- One organism fights another organism for food, land, water.
- Win / Lose OR Lose/Lose

Mutualism

2 organisms benefit from each other

Bee gets food Plant transfers pollen

Win / Win Usually

BUT possibly

Lose/Lose…EXPLAIN!!!

Mimicry

- One organism looks like another

Batesian Mimicry

One **harmless** organism mimics appearance of a harmful organism

Mullerian Mimicry

2+ species have evolved (independently) similar appearances that both confer harm

Evaluate the 2 forms of mimicry by answering the following:

Which is beneficial to both species and why?

Which can be beneficial to one species and harmful to the other? Why?

Use authentic examples to justify your responses.

Ecosystem Distribution

- Continuously changing due to geological & meteorological events.
  - Dinosaurs
  - Continental Drift
  - Desertification

Ecosystem Changes

- The distribution and abundance of populations depends on all the interactions among them along with environmental changes.
  - Too many lion prides in an area leads to intense competition.
  - Succession in communities leads some species to be replaced by others.

Primary Succession:

Secondary Succession:

Loss of Species

1. Invasive species
   - –Outcompete native species
   - –Introduced by humans either accidentally or on purpose

Kudzu: Introduced from Japan to Philadelphia

–Spreading 150,000 acres each year!

–Shades trees/shrubs

–No natural “predators” to limit growth

Loss of Species

2. Habitat Disturbance/Destruction
   - Forest Logging
   - Gold Mining
   - Construction
   - Military Actions
   - Oil Drilling

3. Climate Change
   - Global Warming & Polar Bears
   - Organism reproductive cycles changing